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Individual, Study, and Neighborhood Level Characteristics Associated With Peer Recruitment of Young Illicit Drug Users: Optimizing Respondent Driven Sampling

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Abstract

Recruiting a representative sample using respondent-driven sampling (RDS) relies on successful peer recruitment. While prior studies have identified individual-level characteristics associated with peer recruitment, study- and neighborhood-level factors may also influence peer recruitment. This analysis aimed to identify individual-, study-, and neighborhood-level factors associated with RDS peer recruitment. 390 young adult (18–40 years) heroin, crack and/or cocaine users in New York City (NYC) were recruited via RDS into a cohort study aiming to identify social risk factors for transitioning from non-injection to injection drug use (2006–2009). Individual-level baseline characteristics (demographics, drug use, and network characteristics) and study factors (number of recruitment coupons received and participant attendance at RDS training sessions (RDST) on peer recruitment) were ascertained. Aggregate measures of neighborhood attitudes about drug use, drug users, and HIV were obtained from a separate anonymous NYC resident random-digit-dialing survey (2002) and linked with baseline data by zip code. Descriptive statistics and multilevel modeling were used to identify factors associated with peer recruitment. After adjustment, recruiting each additional eligible peer recruit was associated with receiving additional recruitment coupons, RDST attendance, and a greater proportion of community residents in one's recruitment neighborhood believing that clean needles should be made available to IDUs; heroin use was negatively associated with recruiting additional eligible peers. After adjustment, recruiting each additional peer (regardless of eligibility) was associated with receiving additional recruitment coupons and RDST attendance. Our data highlight the importance of neighborhood factors and suggest that RDS may not be as effective in areas characterized by negative attitudes about drug use. Group-facilitated recruitment training sessions may help counter negative social norms when implementing RDS in drug user studies.

Keywords

Respondent Driven Sampling; neighborhood; HIV; illicit drug users; peer-driven intervention; peer recruitment; USA

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Introduction

The findings from this paper are relevant to the recruitment of "hard-to-reach" or highly marginalized/stigmatized populations for observational studies and prevention interventions. Recruiting a representative sample of illicit drug users for substance abuse or HIV research can be challenging because there is no sampling frame for the target population. Because convenience, targeted, snowball, and time-location sampling methods cannot sample from the target population at random, they may over-sample cooperative respondents, under-sample reclusive ones, and miss those who can only be reached through social networking approaches (Ramirez-Valles, Heckathorn, Vazquez, Diaz, & Campbell, 2005). Respondent-driven sampling (RDS) attempts to minimize these biases through a modified form of chain-referral sampling that regulates peer recruitment and uses dual incentives (e.g., incentives for both participation and peer recruitment) and probability weights to offset nonrandom recruitment (Douglas Heckathorn, 2007). RDS begins with a small sample of "seeds" from the target population. Each seed receives a limited number of study coupons to recruit their peers to the study, who then in turn recruit their peers, and so on. This process of recruits becoming recruiters continues through successive waves and expands geometrically until the target sample size is reached.

RDS has recruited large geographically and demographically diverse samples of injection drug users (IDUs) (Abdul-Quader, Heckathorn, McKnight, Bramson, Nemeth, Sabin et al., 2006;DD Heckathorn, 1997, 2002;DD Heckathorn, Semann, Broadhead, & Hughes, 2002; Johnston, Malekinejad, Kendall, Iuppa, & Rutherford, 2008; Salganik, 2006). RDS has also been used to recruit non-injection drug users, but the representativeness of these samples has not been evaluated (Draus, Siegal, Carlson, Falck, & Wang, 2005; Falck, Siegal, Wang, Carlson, & Draus, 2005).

According to Markov Chain theory, which assumes a single, non-branching, with-replacement, random walk process(Gile & Handcock, 2010), equilibrium, or the point at which the sample composition ceases to change by more than 2% from one recruitment wave to the next for a number of demographic characteristics specified *a priori*, is reached after a successive number of recruitment waves. At equilibrium, the final sample is often claimed to represent the underlying population on major demographic characteristics and be independent of seeds. However, as with other unbiased estimators, RDS estimates are on average unbiased, but may in some cases over- or under-estimate the true effect (Salganik, 2006). The theoretical model is acknowledged to be an approximation because unlike the theoretical model for RDS, in practice, RDS recruitment is branching, without-replacement, and does not begin at, or converge to a fixed equilibrium. Because of the bias induced by non-random selection of seeds, this approximation is recognized to be inaccurate, especially after only a few waves of recruitment (Gile & Handcock, 2010). As this bias is reduced after successive waves of recruitment, long recruitment chains can provide a means for overcoming bias introduced in seed selection.

Because population estimates are often claimed to be unbiased at equilibrium, researchers have considered ways to improve peer recruitment and to increase the speed at which the sample reaches equilibrium. To reduce the number of waves required to reach equilibrium, some suggest selecting a diverse group of seeds with respect to factors that are strongly associated with the formation of social ties (e.g., race/ethnicity, gender, age, drug use) (Frost, Brouwer, Firestone Cruz, Ramos, Ramos, Lozada et al., 2006; Lansky, Abdul-Quader, Cribbin, Hall, Finlayson, Garfein et al., 2007; Ramirez-Valles et al., 2005; Robinson, Risser, McGoy, Becker, Rehman, Jefferson et al., 2006; Wang, Carlson, Falck, Siegal, Rahman, & Li, 2005). Others suggest recruiting seeds from syringe exchange programs and other community-based organizations because individuals affiliated with these

groups are accustomed to referring peers (Ramirez-Valles et al., 2005). Steering incentives, or additional incentives paid for recruiting particularly hard-to-reach members have also been used (Abdul-Quader et al., 2006;DD Heckathorn, 2002;DD Heckathorn et al., 2002). Other studies found that peer recruitment increased when interviewers spent time explaining the significance of the peer recruitment process to participants individually (Ramirez-Valles et al., 2005). While most studies have focused on identifying individual characteristics associated with peer recruitment, the current study developed group-facilitated RDS training sessions (RDSTs) to improve peer recruitment. At RDSTs, study participants learned about the study and discussed and practiced techniques for recruiting peers. A group setting was implemented based on the premise that group interaction and increased social influence during the peer-recruitment training session would result in more efficient peer-recruitment to the study.

Several studies have examined the association between peer recruitment and individual factors such as race, gender, age, education, homelessness and HIV status, but the findings are inconsistent (Broadhead, Heckathorn, Weakliem, Anthony, Madray, Mills et al., 1998; Ramirez-Valles et al., 2005). For example, while several studies show that HIV positive individuals have a greater number of networks than HIV negative individuals (Douglas Heckathorn, 2007; Ramirez-Valles et al., 2005), the relationship between HIV status and peer recruitment varies by study(Abramovitz, Volz, Strathdee, Patterson, Vera, & Frost, 2009; Broadhead et al., 1998;Douglas Heckathorn, 2007; Ramirez-Valles et al., 2005). Neighborhood-level differences may help explain some of these discrepancies. For example, people who are HIV positive may be less likely to recruit peers in neighborhoods with increased stigma towards people living with HIV. Similarly, neighborhoods characterized by a higher tolerance for injection drug use or by more positive attitudes about syringe access may provide a more supportive social environment for recruiting IDUs. This analysis aimed to examine the association between individual-, study-, and neighborhood-level characteristics and the recruitment of eligible drug using networks to participate in a research study. The authors also examined correlates of peer recruitment, regardless of eligibility, because those findings may have greater generalizability to the overall drug using population

MATERIALS AND METHODS

The data for this analysis are from the Social Ties Associated with Risk of Transition into injection drug use (START), a longitudinal study aiming to identify social risk factors for transitioning from non-injection to injection drug use among young adult heroin, crack and cocaine users in New York City. Active drug users were recruited through targeted street outreach and RDS as previously described(Rudolph, Crawford, Latkin, Heimer, Benjamin, Jones et al., 2011); however, this analysis was restricted to the respondent-driven sample.

Between July 2006 and June 2009, 46 RDS seeds were recruited through targeted street outreach in socioeconomically disadvantaged, ethnographically defined neighborhoods in Brooklyn, Bronx, Manhattan, and Queens. Each seed was asked to recruit up to three peers, each of whom were also asked to recruit three additional peers, and so on until recruitment was administratively ended in June 2009. Of 621 participants screened to participate in the respondent-driven sample, 439 were eligible. Participants were initially interviewed at a Harlem community-based site and on a mobile van. However, 32 individuals who were initially enrolled on the van were removed from the analysis because the van's constant relocation made RDS peer referral and follow-up using the van infeasible. Of the 407 remaining, 4 were dropped due to inconsistencies in self-reported drug use (remaining number of participants: N=403). As previously reported, forty-six seeds (28 of whom recruited eligible peers) and a maximum of 14 recruitment waves produced 357 peer-

recruits(Rudolph et al., 2011). Two of the seeds were responsible for recruiting over half the peer recruits in this sample (n=203)(Rudolph et al., 2011). As the purpose of this analysis was to examine peer recruitment, 13 additional individuals were removed because they were recruited at the end of the study and were not given an opportunity to recruit peers, leaving 390 participants in this analysis.

Participants were eligible for START if they were 18–40 years old (verified with a photo ID) and were active injection or non-injection drug users. Eligible IDUs reported injecting heroin, crack or cocaine for less than or equal to four years and injecting at least once in the past 6 months; visible track marks verified injection drug use. NIDUs reported non-injection use of heroin, crack or cocaine for at least one year and using 2–3 times per week in the last 3 months. Self-reported drug use was verified with a rapid drug test which detected the presence of opiate and cocaine metabolites in urine in the two to three days prior to the screener. Those with negative drug screens were not eligible and were compensated for travel to and from the research site.

Individual-level variables

After providing informed consent, eligible START participants completed a 90 minute interviewer-administered questionnaire. This ascertained age (continuous); gender (male *vs*. female); race/ethnicity (Hispanic, Black, White/other); highest level of education achieved (at least high school or the equivalent *vs.* less than high school); combined income (greater than $10,000 per year vs. $10,000 or less per year). homelessness in the past 6 months (binary); HIV status (HIV positive *vs*. HIV negative); Residence (Harlem, Bronx, Brooklyn, Queens, Lower East Side); injection status (IDU *vs.* NIDU)); network characteristics (number of drug using social networks (continuous) and number of people he/she uses drugs with (continuous)); and binary drug use characteristics (any heroin, crack or cocaine use in the past 6 months and daily use of heroin, crack, or cocaine in the past 6 months). All study procedures, consent forms and interviews were approved by the institutional review boards at Columbia University and the New York Academy of Medicine (NYAM). Additionally, a confidentiality certificate was issued to Columbia University in May of 2006 to conduct this research. Following the survey, participants received $30 and a round-trip Metrocard, 3 peer recruitment coupons, a one-on-one peer recruitment training with an interviewer, and an appointment to attend a group-facilitated RDS training session on peer recruitment (RDST).

Study-level variables

For each participant, the interview site, recruitment site, number of RDSTs attended, number of recruitment coupons received, and number of ineligible and eligible peers recruited were entered into the database and merged with the baseline dataset by participant ID.

Respondent Driven Sampling Trainings (RDSTs)—All RDS participants were encouraged to attend at least one RDST. Dual facilitators provided a study overview, described RDS, explained the participant's role in the study, and covered the ethics of peer recruitment. The training session emphasized the importance of recruiting peers into the study and created a comfortable forum for discussing successful recruitment strategies and/or difficulties experienced while recruiting peers. Role plays were also used to help participants demonstrate and practice successful recruiting techniques. Because each group had a mix of participants who had and had not attended previous RDST sessions, those who had been successful recruiting peers were able to share their recruitment strategies with others in the group and those who had previously had difficulties with peer recruitment were able to seek advice from other group members who had been successful. RDST sessions also served to build rapport between participants and the research staff. Trainings typically lasted 45 minutes and light refreshments were provided. Participants were compensated $20 and

round-trip transportation after completing a brief survey at the end of the RDST session that collected information about his/her experiences with peer recruitment and feedback on the group session.

Additional Coupons—After completing the baseline survey, all participants received 3 coupons to recruit peers, however, because many peer recruits were not eligible for the study, participants received additional coupons to recruit eligible peers when their peer recruits were found to be ineligible. While seeds were given as many coupons as were needed to recruit 3 eligible peers, peer recruits were given a maximum of 5 coupons to recruit 3 eligible peers.

Neighborhood-level variables

Neighborhood-level variables were collected as part of a separate community-based structural intervention at NYAM, described previously (Fuller, Galea, Caceres, Blaney, Sisco, & Vlahov, 2007). In brief, an anonymous random-digit-dialing telephone survey was conducted among 979 community residents in East Harlem, Central Harlem, Bronx, and Brooklyn in February 2002. Surveys were 25 minutes long and were approved by NYAM's institutional review board. In addition to demographics, intersection of residence and zip code, respondents were asked about their attitudes and opinions towards drug use, drug users, crime, street-discarded syringes, HIV transmission, and the importance of HIV prevention. Individuals also reported their level of agreement with a series of statements about drug use and drug users and the proportion of individuals who responded affirmatively to each statement were aggregated by zip code (Table 2). Because the purpose of this analysis was to identify factors associated with successful peer recruitment, the zip code corresponding with the neighborhood in which he/she was recruited was more relevant than his/her residential zip code. The number of community residents comprising each neighborhood-level variable ranged from 16 to 153 and was on average 58.

Outcomes

Two peer recruitment outcomes were considered: total number of peer recruits regardless of eligibility (Model I) and total number of eligible peer recruits (Model II). While identifying factors associated with recruiting eligible peers was most relevant to this study, identifying factors associated with the total number peer recruits was also examined because it may be more relevant to RDS studies with less restrictive inclusion criteria, which we believe offers a more broad application to the field.

Data analysis

RDSAT weights account for differences in recruitment and homophily (the propensity for people to recruit others with similar characteristics; e.g. age, gender, race/ethnicity) and for variations in network size, however, only when these differences are measured at the level of the individual. Because this analysis aimed to examine correlates of peer recruitment on multiple levels, RDSAT weights were not utilized.

Descriptive statistics were used to characterize the sample with respect to individual-, study-, and neighborhood-level variables. Linear regression (STATA v9.2) with a clustering variable for zip code and a robust between-cluster variance estimator for cluster-correlated data was used to examine the concurrent impact of individual, study, and neighborhood-level characteristics on each peer recruitment outcome. Community member attitudes about drug use were aggregated by zip code and linked with START data by recruitment area zip code (N=17 clusters and 311 individuals)(StataCorp, 2005). The mean number of individuals per zip code was 4.14 (standard error = 3.35). The minimum number of individuals per cluster was 1 and the majority of individuals (71%) were recruited in two zip

codes (n=120 and n=101). The analysis was also run using GLLAMM (STATA v9.2) with a random intercept for zip code to account for the association between unmeasured spatially correlated variables and peer recruitment, to account for aggregate neighborhood data clustered between zip code, and to account for similarities between individuals recruited within the same zip code (e.g. there are more similarities in the baseline risk for those recruited in the same zip code than for those recruited in different zip codes), however these results are not presented (StataCorp, 2005).

RESULTS

As previously reported, equilibrium was reached for all variables examined (gender, race, education, income, age, homelessness, HIV status, injection status, heroin use, cocaine use and crack use). Additionally, there were no major differences in homophily or drug-using network size by any variables considered and no significant differences between the RDS-weighted population estimates and sample estimates for any of these variables(Rudolph et al., 2011). The RDS assumptions were also evaluated for this study and have been reported elsewhere(Rudolph et al., 2011).

Table 1 describes the study population by individual-level characteristics, study-level variables, and neighborhood-level attitudes and beliefs about drug use and drug users. The sample's median age was 35, 75% were male, the majority were black (54%) or Hispanic (37%), 52% had at least a high school degree or the equivalent, 85% reported an annual income less than or equal to $10,000, 11% were HIV positive, and 9% injected. In the past 6 months, 66% reported being homeless, 49% used heroin, 77% used cocaine, and 84% used crack. The majority resided in Harlem (55%), followed by the Bronx (21%) and Brooklyn (16%). The median number of drug using networks, defined as the sum of the number of drug networks and social support networks who use drugs, was 1. Most participants were recruited in Harlem (75%), interviewed at the Harlem community-based site (97%), given three recruitment coupons (71%), and attended at least one RDST (78%). Neighborhood attitudes suggest a low tolerance of adult drug use and predominantly negative attitudes about drug use and drug users. The median number of peer recruits was 1 [Interquartile range (IQR):0–3] and the median number of eligible peer recruits was 0.5 (IQR:0–2) (data not shown). Reasons for ineligibility included self-reported use of non-injection drugs less than 2–3 times per week (60.9%), not having injected in the past 6 months (30.5%), injecting drugs greater than 4 years (0.8%), and negative drug screens despite meeting the eligibility criteria based on self-reported drug use (7.8%) (data not shown).

Table 2 displays factors associated with: 1) recruiting each additional peer regardless of eligibility (Model I), and 2) recruiting each additional eligible peer (Model II), after accounting for clustering by recruitment neighborhood. Drug network characteristics were not significantly associated with either outcome. Before adjusting for other covariates, significant correlates of recruiting each additional peer (regardless of eligibility) included receiving more than three recruitment coupons [Risk Ratio (RR) =14.52], RDST attendance (RR=2.92), and being recruited from neighborhoods characterized by more positive attitudes about sterile syringe availability for drug users (RR=18.64). While individual-level variables were not significantly associated with the total number of peer recruits (regardless of eligibility), injection drug use (RR=0.62), a total annual income greater than $10,000 (RR=0.80) and heroin use (RR=0.70) were associated with recruiting fewer eligible peers and crack use was associated with recruiting additional eligible peers (RR=1.32). Findings from a sub-analysis reveal significant differences in the reasons for ineligibility among recruits of those who did and did not use heroin (p=0.01). Those recruited by heroin users were ineligible because they self-reported infrequent non-injection drug use (49.3%) or because they had not recently injected (41.8%). Other reasons included injecting drugs

greater than 4 years (1.5%) and negative drug screens despite eligibility based on self-reported drug use (7.5%). Peer recruits of those not using heroin were ineligible because of infrequent non-injection drug use (74.6%), no recent injection drug use (17.0%), or because of negative drug screens (8.5%) (data not shown).

Study-level factors associated with recruiting each additional eligible peer included receiving more than 3 recruitment coupons (RR=2.55) and attending at least1 RDST (RR=2.09). In addition, those recruited from neighborhoods characterized by more positive attitudes about sterile syringe availability for drug users (RR=4.98) were more likely to recruit eligible peers.

The final models (Table 3) account for clustering by recruitment neighborhood with a clustering variable for zip code, adjust the standard error estimates for the empirical estimates of the within zip code correlation structure, and adjust for other factors associated with successful peer recruitment. In Model I, after adjustment, recruiting each additional peer was associated with receiving more than three recruitment coupons [Adjusted Risk Ratio (ARR)]:12.63; [95% Confidence Interval (95%CI):9.69,16.47], and RDST attendance (ARR:1.97; 95%CI:1.54,2.53). Although not statistically significant, in this model, being recruited from a neighborhood with an increased proportion of individuals believing that clean needles should be made available to drug users was positively associated with recruiting additional peers (ARR:4.33; 95%CI:0.85,21.98). The results from Model II were very similar. After adjustment, recruiting each additional eligible peer recruit was associated with receiving more than three recruitment coupons (ARR:2.26; 95%CI:1.94,2.64), RDST attendance (ARR:1.90; 95%CI:1.46,2.48), and a greater proportion of individuals in one's recruitment neighborhood believing that clean needles should be made available to drug users (ARR:3.83; 95%CI:1.42,10.31). While individual factors were not associated with the number of recruitment attempts after adjustment (Model I), heroin use was negatively associated with recruiting additional eligible peers (Model II) in the multivariate model (ARR:0.69; 95%CI:0.58,0.81).

DISCUSSION

These data highlight the influence of both study- and neighborhood-level characteristics on peer recruitment and support a need for formative research prior to implementing RDS studies, particularly those among extremely hidden and marginalized populations. Such research will likely provide insight into which interventions would be most effective and efficient in different recruitment settings.

Study-level

Receiving additional recruitment coupons and RDST attendance were associated with recruitment success in both models (i.e., number of peers [I] and number of eligible peers [II]). The magnitude of the association between receiving additional coupons and peer recruitment in Model I was larger than that in Model II, which likely reflects the more narrow definition of the outcome variable in Model II. Additionally, as individuals received additional coupons when peer recruits were not eligible, we would expect that the total number of ineligible peer recruits would be associated with receiving additional coupons. Individuals with more ineligible recruits received additional coupons and those who received additional coupons were also more likely to recruit additional peers. Thus, the direction of the association observed in Model I is unclear. However, participants who recruited eligible peers were not given additional coupons, so the causal direction of this relationship in Model II is more clear; those who received additional coupons recruited more eligible peers than those who did not receive additional coupons. A difference in magnitude by outcome variable was not observed for the association between peer recruitment and

RDST attendance, indicating that RDST attendance enhanced peer recruitment regardless of the eligibility criteria.

While receiving additional recruitment coupons and RDST attendance both increased peer recruitment, only RDST attendance improved the probability that those recruited would be eligible for the study and was a more effective intervention for this study. Among those attending RDSTs, 60% of peer recruits were eligible, compared with 52% of those recruited by individuals not attending RDST (data not shown). Reasons for ineligibility among peer recruits did not differ by RDST attendance ($p=0.84$). On the contrary, while receiving additional coupons increased both the number of individuals recruited and the number of eligible participants recruited, the probability that those recruited would be eligible for START was lower for those given additional coupons (46.2%) than it was for those receiving only 3 coupons (81.9%) (data not shown). It is possible that the first few peers approached by a study participant were more likely to meet the strict criteria because they were more similar to their peer recruit with respect to drug use. These findings suggest that spending additional study resources on dispensing coupons may not be the most efficient approach.

Individual-level

Heroin use was an independent correlate of recruiting eligible peers, but not of peer recruitment in general. While participants using heroin were less likely than those not using heroin to recruit eligible peers, they were not less likely to recruit peers in general. A sub-analysis revealed that ineligible participants recruited by heroin users and non-users were significantly different. Those recruited by heroin users were more likely to be ineligible because they had not recently injected, while those recruited by those not using heroin were more likely to be ineligible because they did not use non-injection drugs frequently.

Neighborhood-level

Individuals recruited in neighborhoods with more positive attitudes about drug use and drug users (specifically related to syringe availability for IDUs) were more likely to recruit peers in both models. Such positive attitudes may correspond with a greater prevalence of injection drug use in these neighborhoods since they may be collectively more tolerant of syringe access for IDUs. Additionally, it is not clear from this analysis whether more positive attitudes about syringe availability for IDUs in the neighborhoods where participants were recruited is motivating recruitment success or whether this measure is a proxy for other unmeasured factors that improve peer recruitment. However, given that the association between neighborhood attitudes/norms and peer recruitment for an RDS study has not previously been examined, these findings suggest that neighborhood factors may play a role in determining whether RDS can be successfully implemented in the field. Future studies should explore these and other salient neighborhood-level indicators and their influence on RDS peer recruitment.

Considering the large number of clusters and small variance in the neighborhood-level effects investigated, it is plausible that we were under-powered to detect significant variation and that other neighborhood factors may also be important. As a result, our findings are probably indicative rather than conclusive. Of note, the point estimates from random effects models with a random intercept for recruitment zip code resulted in similar findings, except that the point estimate for the neighborhood variable in Model I was statistically significant ($p<0.05$). Future studies should consider using a larger sample size to assess the influence of other neighborhood attitudes on peer recruitment.

Limitations

Because this study aimed to enroll young, frequent drug users and newly initiated IDUs, the study eligibility criteria required that non-injection drug users screen positive for heroin, crack, or cocaine and that IDUs inject for fewer than 4 years. As a result, a large proportion of individuals who were screened for this study were not eligible to participate (71% overall and 41% of peer recruits). The researchers responded to these early difficulties with peer recruitment by developing and implementing RDSTs, which proved effective in boosting peer recruitment and could be used in future studies facing similar challenges. Of note, while this study aimed to provide valuable information to improve peer recruitment in an RDS study, our findings may not be generalizable to all RDS studies with peer recruitment challenges stemming from behaviors that are illegal or widely deemed to be socially unacceptable (e.g., sex workers, men who have sex with men). As previously indicated, formative research could assist in translating these methods to other settings and populations and should be explored.

As sociodemographic characteristics, drug use behaviors, and social network measures were determined by self-report, there is a potential for individuals to be misclassified due to inaccurate reporting (i.e., over-report of socially desirable responses and under-report of stigmatizing ones). However, previous work has shown that self-reports of HIV risk behaviors are generally reliable (Goldstein, Friedman, Neaigus, Jose, Ildefonso, & Curtis, 1995). In addition, we observed a number of high risk behaviors and the proportions of individuals reporting these behaviors were consistent with previous studies in this population, which suggests that this bias may be minimal.

It is also possible that those attending RDSTs were more likely to recruit individuals to the study for reasons unexplored here (e.g., study compliance) and not because of the information and skills acquired from trainings. This possibility should not negate these findings, but should be explored in future studies that randomize participants to receive RDSTs to account for this possible bias. As RDSTs were implemented in response to difficulties with peer recruitment and not prior to the study, the intervention assignment was not randomized. While all individuals were encouraged to attend the RDSTs, the process of assignment into the “intervention” was through self-selection. As a consequence, those who chose to attend RDSTs may have been different than those who chose not to attend them, and these differences may also be associated with his/her ability to recruit peers. However, self-selection into the intervention group could also be viewed more positively, as it may more accurately reflect the effectiveness of the trainings in the absence of regulation. Additionally, even if individuals were randomized to attend RDSTs, there would be a large potential for contamination, because individuals are recruited by their peers. Thus, an individual who was not randomly assigned to attend RDST, but who used drugs with another participant or who was recruited by an individual who was randomly assigned to attend RDST might look more similar to those who were randomly assigned to receive RDST than to those who were not. A comparison of those who did and did not attend RDST revealed significant differences by age, race/ethnicity, and self-reported HIV status but not by any other demographic variables considered (data not shown). Those who attended RDSTs were older and more likely to self-report being positive for HIV. Blacks were more likely to attend RDSTs and Hispanics were less likely to attend RDSTs. As these variables were not associated with peer recruitment success, there is no evidence to suggest bias through self-selection.

Additionally, it is possible that the neighborhood-level data collected in 2002 did not accurately represent the attitudes and behaviors of those in the same neighborhoods between 2006 and 2009. There is some evidence to suggest that drug use increased following the terrorist attacks on September 11, 2001(Deren, Shedlin, Hamilton, & Hagan, 2002; Vlahov,

Galea, Resnick, Ahern, Boscarino, Bucuvalas et al., 2002). As a consequence, the observed attitudes and opinions about drug use and drug users that were collected in 2002 may either over- or underestimate those that would have been observed between 2006 and 2009 when the START data were collected. However, the estimates were unchanged when a random intercept was used to account for similarities in neighborhood attitudes. In a model that incorporates a random intercept, the random intercept will change, but the measured effect will be unbiased as long as we do not expect that some neighborhoods experience greater shifts in their attitudes about drug use and drug users than others. This assumption is supported by the narrow IQRs in table 1, which suggests a lack of heterogeneity in attitudes about drug use and drug users by zip code in this analysis. Finally, as the majority of the participants included in this analysis were recruited from Harlem, our findings may not be generalizable to other neighborhoods, cities, or other geographic regions. While it is likely that the same factors will play an important role in recruitment, their relative influence may vary.

Strengths

Unlike most prior studies which have focused on individual-level factors associated with peer recruitment, this study was distinctive because it also examined the influence of study-level and neighborhood-level factors on peer recruitment success. This study also used a separate data set to explore subjective neighborhood perceptions, which can be considered a strength because the possibility of same-source bias was avoided (A. V. Diez Roux, 2003; A.V. Diez Roux, 2007). Measurement error due to individual subjectivity was also reduced because neighborhood social norms were collected from a different set of respondents using a separate survey(Mujahid, Diez Roux, Morenoff, & Raghunathan, 2007). In addition, this is the first study to develop and evaluate group-facilitated training sessions as a tool to optimize peer recruitment.

Conclusion

With limitations acknowledged, this analysis suggests that study- and neighborhood-level characteristics significantly influence peer recruitment success and determine the likelihood that RDS will be successful. Individual characteristics were less important and largely reflected study eligibility criteria. When peer recruits were not eligible to participate in the study, peer recruiters expressed frustration because 1) their street credibility was diminished and/or 2) the recruitment process was time consuming. As RDS relies completely on peer recruitment and because individuals were often discouraged from recruiting additional peers when those who they had previously recruited were not eligible to participate in the study, RDSTs were critically important to generate enthusiasm for the study and to build rapport between research participants and study personnel. By encouraging participants to recruit additional peers, RDSTs substantially increased peer recruitment, facilitated the extension of recruitment chains, and contributed to the recruitment of a more diverse sample. For example, two seeds initiated referral chains extending at least13 waves and were responsible for recruiting over half of the peer recruits (n=203); five seeds (extending at least 6 waves each) recruited 255 individuals (71%) and 311 individuals were recruited by 10 seeds with recruitment waves extending at least 4 waves (87%)(Rudolph et al., 2011). Thus, RDST attendance by 78% of study participants may explain why equilibrium was reached for all variables considered. While RDSTs were essential in our study, they may not be necessary for other studies with less restrictive eligibility criteria or that recruit individuals in an environment that is more receptive to drug use. However, in this study, administering additional study coupons and implementing a group training session on peer recruitment improved both recruitment efforts and recruitment success and could be implemented by others who face similar problems in the field.

The implications of these findings are also relevant for HIV prevention studies that use network-driven approaches to deliver intervention messages, a strategy that has become increasingly common(Bell, Atkinson, & Mosier, 2002; Booth, Lehman, Latkin, Dvoryak, Brewster, Royer et al.,; Robert S. Broadhead & Heckathorn, 1994; Robert S. Broadhead, Heckathorn, Grund, Stern, & et al., 1995; R. S. Broadhead et al., 1998; Cottler, Compton, Ben Abdallah, Cunningham-Williams, Abram, Fichtenbaum et al., 1998; Coyle, Needle, & Normand, 1998; Deering, Shannon, Sinclair, Parsad, Gilbert, & Tyndall, 2009; C. Latkin, Mandell, Oziemkowska, Celentano, Vlahov, Ensminger et al., 1995; C. A. Latkin, Sherman, & Knowlton, 2003; Neaigus, 1998; Robert, Valerii, Tamara, Marina, Casey, Yael van et al., 2006). For example, group training sessions that facilitate discussions about HIV prevention and help participants deliver intervention messages to more people would expand the reach of an intervention and could reduce disease transmission and high-risk behaviors among many more individuals in the target population.

Despite overwhelmingly negative attitudes about drug use and drug users in the neighborhoods where illicit drug users were recruited for this study, study-imposed variables, mainly RDST attendance, helped participants surmount these recruiting obstacles. As results were dramatic when 78% of participants attended RDSTs, increased participation may further optimize peer recruitment. Formative work can help researchers to better understand community attitudes about drug use and drug users to better inform research strategies for recruitment. In the future, studies utilizing RDSTs should also focus on increasing RDST attendance and those without the capacity to develop and implement RDSTs should focus more on formative work and consider the impact of neighborhood attitudes and opinions toward drug users and about drug use, more generally. As this study demonstrates, RDSTs could be used to 1) boost peer recruitment for RDS studies conducted in neighborhoods where stigma may serve as a barrier for successful recruitment or where recruitment is hindered by strict eligibility criteria and 2) facilitate the dissemination of intervention materials and messages through peer-driven intervention studies conducted in neighborhoods with increased stigma.

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Table 1

Prevalence of Individual, Study, and Neighborhood Level Correlates of Peer Recruitment, New York City, 2006–2009. (N=390)

	N	%
Individual Level Variables		
Median Age (IQR)	35	29–38
Gender		
Male	290	74.6
Female	99	25.4
Race/ethnicity		
Hispanic	143	36.7
Black	211	54.1
White/Other	36	9.2
Education		
Less than high school	186	57.4
At least high school or the equivalent	204	52.3
Combined income (taxed + untaxed)		
Less than or equal to $10,000	311	84.7
Greater than $10,000	56	15.3
Homeless (past 6 months)		
No	131	33.6
Yes	259	66.4
HIV status		
Negative	322	89.4
Positive	38	10.6
Residence		
Harlem	196	54.9
Bronx	74	20.7
Brooklyn	58	16.3
Queens	16	4.5
Lower East Side	13	3.6
IDU		
No	355	91.0
Yes	35	9.0
Use Heroin (alone or with crack/cocaine)		
No	198	51.3
Yes	188	48.7
Daily heroin use (alone or with crack/cocaine)		
No	328	84.1
Yes	62	15.9
Use Cocaine (alone or with heroin)		
No	89	22.9

	N	%
Yes	299	77.1
Daily cocaine use (alone or with heroin)		
No	351	90.0
Yes	39	10.0
Use Crack (alone or with heroin)		
No	60	15.9
Yes	329	84.1
Daily crack use (alone or with heroin)		
No	244	62.6
Yes	146	37.3
Drug Network Characteristics		
Median number of people use drugs with (IQR)	1	0–2
Median number of social networks who use drugs (IQR)	1	0–2
Study Level Variables		
Recruitment site		
Harlem	257	75.2
Bronx	34	9.9
Brooklyn	25	7.3
Queens	10	2.9
LES	16	4.7
Interview site		
Storefront	377	96.7
Van	13	3.3
Median Number of Coupons Given (IQR)	3	3–5
Given additional coupons (more than 3)		
No	278	71.3
Yes	112	28.7
Attended RDS group training (RDST)		
No	87	22.3
Yes	303	77.7
Participant type		
Peer recruit	344	88.2
Seed	46	11.8
Neighborhood Level Variables	Median	IQR
Proportion of neighborhood sample who_____		
Live near a syringe exchange program	0.12	0.05–0.14
Tolerate adult illicit drug use	0.00	0.00–0.02
Disagree that people abusing drugs/alcohol are more dangerous	0.31	0.30–0.44
Disagree that people can stop using drugs whenever they want	0.72	0.69–0.77
Disagree that those abusing alcohol/drugs lack self control	0.28	0.23–0.28

	N	%
Disagree that alcohol/drug abuse leads people to commit crimes	0.32	0.22–0.32
Do not look down on those hospitalized for drug/alcohol problems	0.41	0.41–0.48
Tolerate having a neighbor who abuses alcohol/drugs	0.30	0.20–0.33
Are against more severe criminal penalties for illicit drug users	0.63	0.54–0.63
Disagree that there should be more mandatory drug testing at work	0.36	0.29–0.38
Are against more aggressive police sweeps to arrest drug users	0.38	0.24–0.38
Feel making clean needles available to IDUs is important	0.48	0.48–0.63

Abbreviations: HIV, Human Immunodeficiency Virus; IDU, injection drug user; IQR, Interquartile Range; RDS, Respondent Driven Sampling; RDST, Respondent Driven Sampling Training

Table 2

Individual, Study, and Neighborhood Level Correlates of Peer Recruitment, New York City, 2006–2009. (N=311)

	Model I Total Number of Recruits (Eligible/Ineligible)		Model II Total Number of Eligible Recruits	
	RR	**95%CI**	**RR**	**95%CI**
Individual Variables				
Age	0.99	0.93, 1.06	1.00	0.96, 1.05
Male vs. Female	1.36	0.84, 2.19	0.97	0.73, 1.27
Hispanic vs. White	0.92	0.67, 1.26	0.82	0.48, 1.40
Black vs. White	1.06	0.78, 1.43	1.12	0.63, 1.96
High school or more	0.97	0.68, 1.39	1.01	0.79, 1.29
Total income greater than $10,000 per year	0.87	0.57, 1.33	0.80	0.70, 0.92
Homeless in past 6 months	1.22	0.92, 1.63	1.11	0.90, 1.36
HIV positive	1.45	0.68, 3.11	1.42	0.95, 2.12
Inject	0.69	0.31, 1.55	0.62	0.48, 0.79
Heroin use in past 6 months	0.82	0.53, 1.28	0.70	0.55, 0.89
Cocaine use in Past 6 months	1.04	0.70, 1.54	0.79	0.58, 1.09
Crack use in past 6 months	1.13	0.88, 1.43	1.32	1.01, 1.73
Drug Network Characteristics				
# People use drug with	1.05	0.92, 1.20	1.05	0.99, 1.12
# Drug using social networks	1.03	0.94, 1.13	1.01	0.97, 1.05
Study Variables				
Number of coupons given	4.95	4.01, 6.10	1.61	1.40, 1.86
4 or more coupons vs. 3 coupons received	14.52	11.50, 18.33	2.55	2.5, 2.90
Attend at least one training	2.92	1.96, 4.34	2.09	1.59, 2.75
Seed vs. peer recruit	1.28	0.55, 3.00	1.02	0.69, 1.50
Neighborhood Variables				
Proportion of neighborhood sample who_____				
Disagrees that people abusing drugs/alcohol are more dangerous	0.28	0.01, 7.21	0.88	0.23, 3.36
Disagrees that people can stop using drugs whenever they want	0.06	0.00, 51.20	1.80	0.06, 53.13
Disagrees that those abusing alcohol/drugs lack self control	0.00	0.00, 2.99	0.45	0.01, 24.57
Disagree that those abusing alcohol/drugs are more likely to commit crimes	0.10	0.00, 12.19	1.15	0.11, 3.92
Does not look down on those hospitalized for drug/ alcohol problems	3.98	0.11, 145.51	0.66	0.11, 4.00
Tolerates having a neighbor who abuses alcohol/drugs	2.93	0.06, 138.55	1.03	0.23, 4.60
Are against more severe criminal penalties for illicit drug users	0.82	0.05, 12.28	3.61	1.24, 10.51
Disagrees that there should be more mandatory drug testing at work	0.89	0.00, 159.50	6.13	0.63, 59.70

	Model I Total Number of Recruits (Eligible/Ineligible)		Model II Total Number of Eligible Recruits	
	RR	**95%CI**	**RR**	**95%CI**
Are against more aggressive police sweeps to arrest drug users	0.09	0.01, 1.33	0.89	0.18, 4.49
Feels making clean needles available to IDUs is important	18.64	1.18, 295.12	4.98	1.61, 15.45

Abbreviations: CI, confidence interval; HIV, Human Immunodeficiency Virus; IDU, injection drug user; IQR, Interquartile Range; RR, Risk Ratio

Table 3

Final Multi-level Model for Individual, Study, and Neighborhood Level Correlates of Peer Recruitment, New York City, 2006–2009.

Final Model	Total Number of Recruits (Eligible/ Ineligible) Model I N=309		Total Number of Eligible Recruits Model II N=311	
	ARR	95%CI	ARR	95%CI
Proportion of neighborhood sample who feels making clean needles available to IDUs is important	4.33	0.85, 21.98	3.83	1.42, 10.31
4 or more coupons vs. 3 coupons received	12.63	9.69, 16.47	2.26	1.94, 2.64
Attend at least one training	1.97	1.54, 2.53	1.90	1.46, 2.48
Heroin use in past 6 months			0.69	0.58, 0.81

Abbreviations: ARR, Adjusted Risk Ratio; CI, confidence interval; IDU, injection drug use